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AN ASSESSMENT OF THE *Ambrosia* L. POLLEN THREAT AT A REGIONAL SCALE USING THE EXAMPLE OF THE TOWN OF SOSNOWIEC (SILESIAN UPLANDS, POLAND)

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Abstract

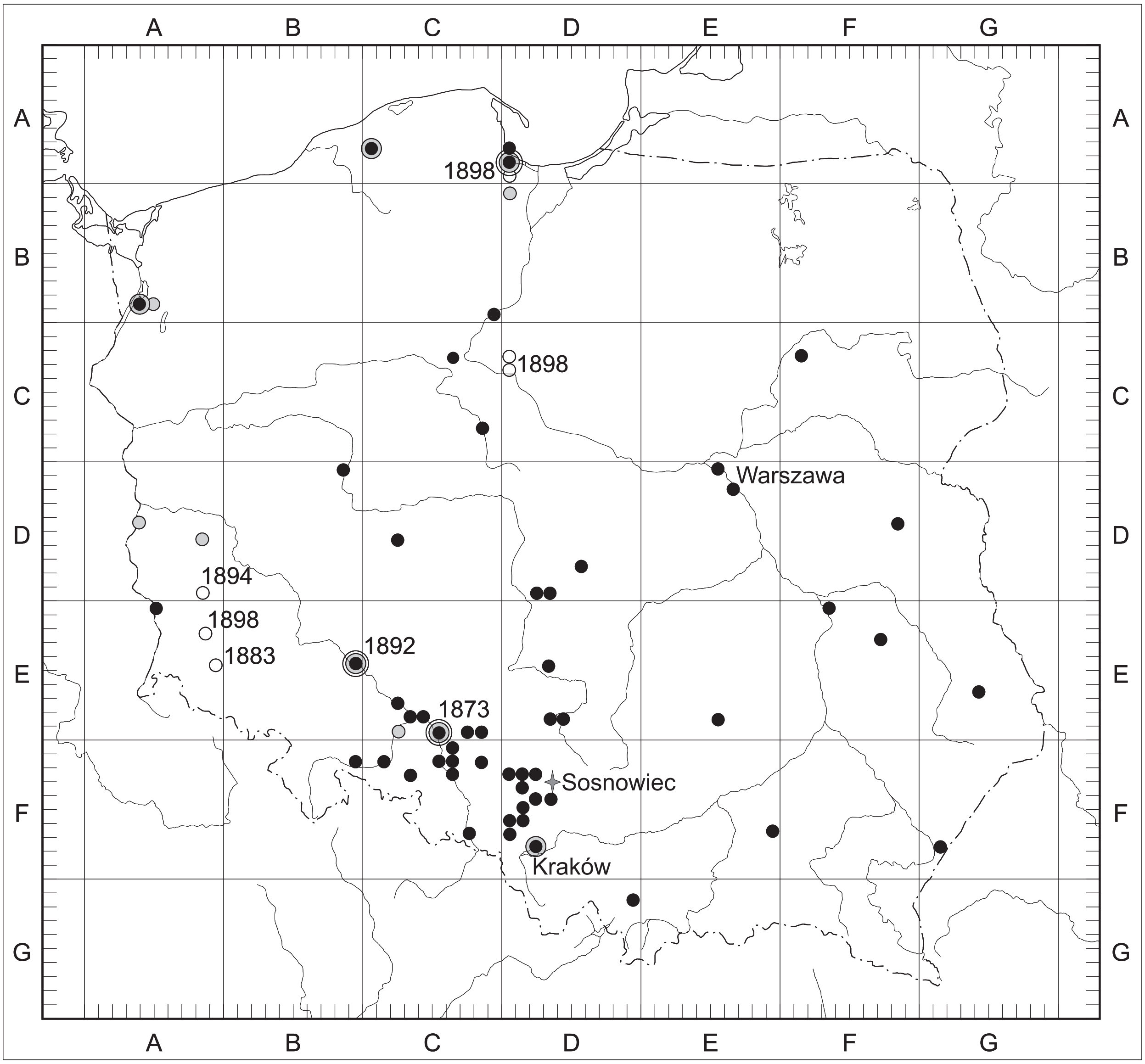
The investigation of *Ambrosia* pollen counts in the air of Sosnowiec was carried out from 1998 to 2010 by means of the volumetric method. The pollen season which was determined by means of the 98% method started at the end of July and the beginning of August and lasted until the end of October. The highest *Ambrosia* pollen count was recorded in 1999 (222 grains x m^{-3}) and the lowest in 2001 (18 grains x m^{-3}). It was stated that the daily count of pollen grains depended on the wind direction and maximum air temperature. The strongest correlations were found with maximum temperature and with a wind direction from the south east. A high negative correlation coefficient was found between the frequency of inflows of air masses from the west and the annual total of pollen grains and the value of the maximum daily count. The closest sites of *Ambrosia* L. are at a distance of 25–40 kilometres from the sampling point. Significant correlations with the frequency of inflow of air masses can support the conclusion that *Ambrosia* pollen grains recorded in Sosnowiec were most probably carried not only from local sources but also, at least in part, from distant places.

Key words: aerobiology, *Ambrosia*, pollen count, meteorological parameters, invasive plant, Sosnowiec Poland

INTRODUCTION

Ragweed pollen allergens cause severe allergies and they are counted among the most harmful in the world. In central and southern Europe, they are often a cause of allergic rhinitis and conjunctivitis (Peternel et al. 2008; Testi et al. 2009). In North America, they are the most frequent cause of pollinosis. Since the 1960s, ragweed pollen has been recorded in many European countries: France, northern Italy, southern Austria, the Czech Republic, Slovakia, the Balkan countries, Ukraine, and Hungary. An allergy to ragweed pollen allergens is considered to be a significant problem in the countries of central Europe (Boehme et al. 2009). In Poland, ragweed pollen has been recorded every year in the air of many cities since the 1990s (Kasprzyk, 1996; Malkiewicz and Wąsowicz, 2003; Weryszko-Chmielewska et al. 2003; Weryszko-Chmielewska, 2006; Lipiec et al. 2008; Rapiejko et al. 2009). The frequency of allergies to ragweed pollen allergens in Poland has not been thoroughly examined. In the Warsaw population, an increase in the frequency of positive skin tests with the ragweed pollen allergen has been observed, from 0.3% in 1998 to 1.5% in 2003 (Rapiejko et al. 2006; Lipiec et al. 2008).

The *Ambrosia* genus of the composite family (Asteraceae) has 35–40 species (Willis, 1973). They are anemophilous annual or perennial plants. Unisexual female flowers, which form pseudanthium inflorescences, appear in late summer or early autumn on shoot apices. Male flowers form leafless spikes or racemes in the upper, leafless part of a shoot. One stamen of a flower produces on average 3,375 pollen grains and one inflorescence – 16,875. A plant with 20 racemes may release approximately 420 million pollen grains (Weryszko-Chmielewska and Piotrowska, 2008). The representatives of the *Ambrosia* genus are found in both the Americas and in Africa. In Europe, they appeared in the second half of the nineteenth century due to the import of corn, soya, clover, and also in ballast (Schwarz, 1967). Since the Second World War, they have spread in many regions in southern and south-western Europe. Several species have spread beyond their natural range so widely that they have become cosmopolitan synanthropic plants (Tacik, 1971).



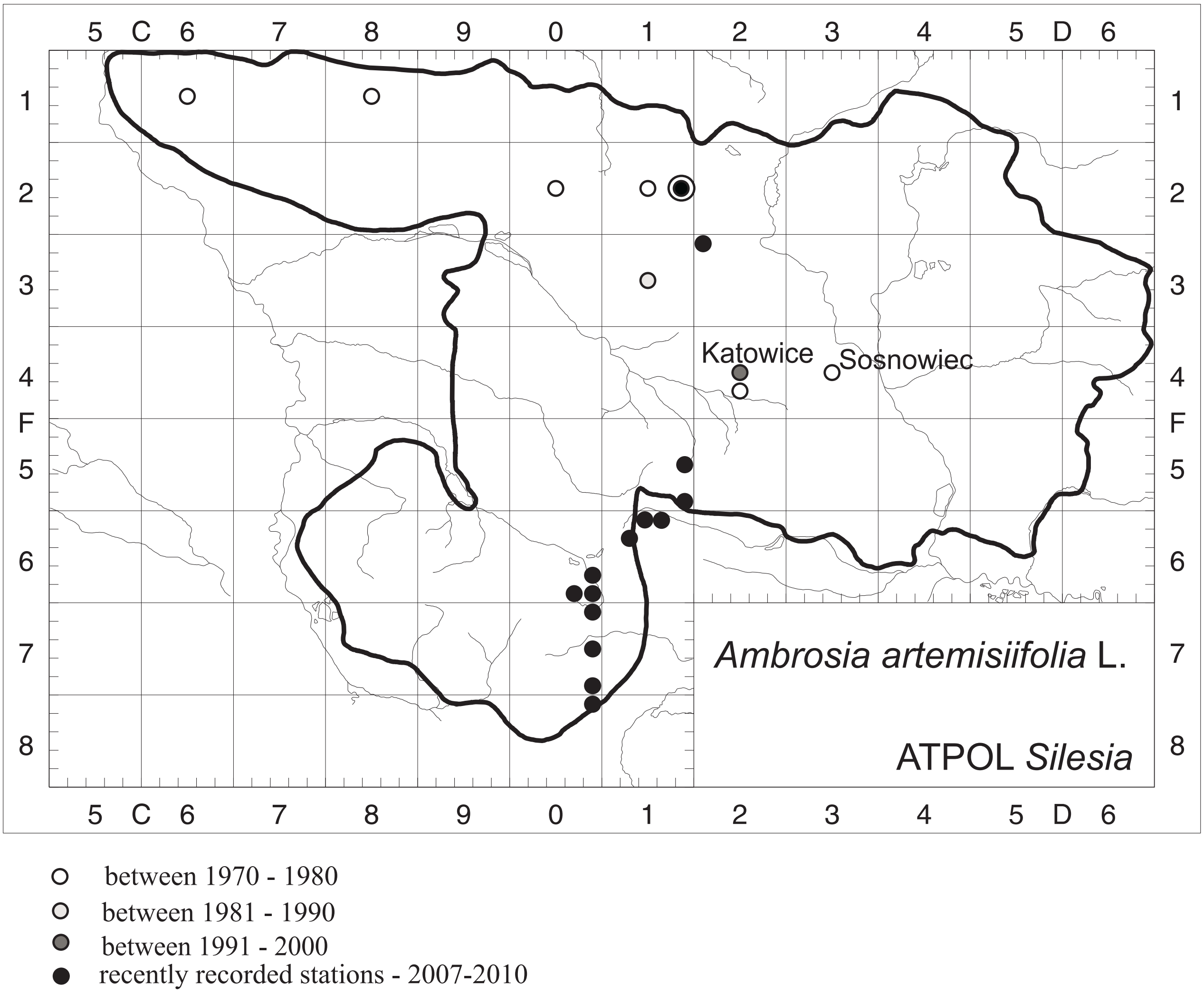
○ between 1851 and 1900
◉ between 1901 and 1950
● between 1951and 2009

Source: Tokarska-Guzik et al. 2011

Fig. 1. Recorded history of the spread of *Ambrosia artemisiifolia* L. in Poland drawn for the consecutive time periods.

In Poland, three species of the *Ambrosia* genus have been found so far: *A. artemisiifolia* L., *A. psilostachya* DC. = *A. coronopifolia* Torr. & A. Gray and *A. trifida* L. (Mirek et al. 2002). The first two species have the status of naturalized species in our country (Tokarska-Guzik, 2005; Zając et al. 1978), while *A. trifida* L. is treated as a casual species (Mirek et al. 2002; Rostański and Sowa, 1986-1987). In Poland, the species most often found is *Ambrosia artemisiifolia* L. The first localities for this species were recorded in the second half of the nineteenth century in the western, south-western and northern part of the country. Currently, this species is scattered all over lowland Poland (Tokarska-Guzik, 2001) (Fig. 1). In the region of Upper Silesia, the first site of *Ambrosia artemisiifolia* was recorded in 1921 in Pszczyna (Lindner 1921, *herb*. WRSL*). The next were recorded in Sosnowiec (Sowa and Wójcik, 1969; Majcher 1974, *herb*. LBL*), Tarnowskie Góry (Sendek, 1971, 1973; Tokarska-Guzik, 1999 unpublished data), Pyskowice (Michalak and Sendek, 1974-1975) Katowice – Stary Panewnik (Bołdys, 1978, unpublished data), Zabrze – Biskupice (Sendek, 1984), Katowice

– Kokociniec (T o k a r s k a - G u z i k 2000, *herb.* KTU*) and – outside the Katowice conurbation – in Częstochowa (M i c h a l a k and S e n d e k, 1974-1975; P i a s e c k i 1986, unpublished data). Currently, new localities of ragweed have been found along the national road between Katowice and Cieszyn at a distance of approximately 25-40 kilometres SW from the sampling point (see Materials and Methods) and one locality has been confirmed on a railway siding in Tarnowskie Góry at a distance of approximately 25 kilometres NW from the sampling point (Fig. 2).



Source: Tokarska-Guzik et al. 2011

Fig. 2. Recorded history of the spread of *Ambrosia artemisiifolia* L. in the Silesian Uplands drawn for the consecutive time periods.

Ambrosia psilostachya is a species less frequently recorded. It was brought to Europe a little later. The first records come from Poland in 1901 (T o k a r s k a - G u z i k, 2005) and from Great Britain in 1903 (S t a c e, 1997). By 2000 it was recorded in between ten and twenty scattered places (T o k a r s k a - G u z i k, 2001). However, it is expanding only locally. The only site of this species in the region of the Katowice conurbation was recorded in Chorzów (S e n d e k, 1973; S e n d e k 1971, *herb.* MGS*).

The aim of the present study was to assess the threat of ragweed pollen on local and regional scales. The paper contains an analysis of ragweed pollen seasons in Sosnowiec (southern Poland) on the basis of data from 1998 to 2010. Additionally, the impact of selected meteorological parameters on this pollen count was examined.

* Abbreviations for herbarium materials are explained in the Materials and Methods chapter

MATERIALS AND METHODS

The *Ambrosia* L. pollen count data come from pollen monitoring in 1998-2010. The pollen count in the air of Sosnowiec was measured by means of the volumetric method using a Burkard spore trap (Hirst-type). The beginning and the end of the pollen season was determined by means of the 98% method. To compare the pollen counts over the studied years, a Seasonal Pollen Index (SPI) was calculated as the sum of the daily pollen counts in a given season. The sampling point is located in a district of Sosnowiec with well-spaced blocks of flats. The spore trap is at a height of approximately 20 metres above the ground level on the premises of the Faculty of Earth Sciences at the University of Silesia (263 metres above sea level, 50º17’ 50”N and 19º08’ 20”E). Meteorological data were delivered by a weather station which is about 20 m from the sampling point.

In the Silesian Uplands area, where Sosnowiec is situated, the influences of various air masses interact, therefore the climate is characterized by quite considerable variability and irregularity in the course of climatic elements. Sosnowiec is situated in a temperate climate zone – it has a climate transitional between oceanic and continental. On the majority of days throughout the year (63.5%) the weather in Sosnowiec is determined by polar maritime air (Niedźwiedź, 2003). Average annual temperature is 8.1ºC. The warmest month is July (17.2ºC) and the coldest – January (-1.2ºC). The average annual precipitation is about 700 mm. The dominant winds are westerly ones: NW, W and SW (Łupikasza and Widawski, 2008).

The average daily values of air temperature, relative humidity, precipitation, insolation, wind speed and direction were taken into account to assess the impact of meteorological parameters on selected characteristics of the pollen seasons. Furthermore, the direction and type of atmospheric circulation were subjected to analysis (Niedźwiedź, 1981). The relationships between individual meteorological parameters and various characteristics of the pollen season in all years were determined by means of Spearman’s rank correlation coefficient (Stanisz, 2007).

The data about the history of the appearance and further spread of the species of the *Ambrosia* genus in the Silesian Uplands area (especially *A. artemisiifolia*) come from original observations and all relevant published, unpublished and herbarium data obtained by other researchers (Tokarska-Guzik, 2005; Tokarska-Guzik et al. 2011). The unpublished materials sent to the database “Distribution Atlas of Vascular Plants in Poland – ATPOL” (Zając and Zając, 2001) by botanists from all over Poland and the data gathered on the basis of our own floristic surveys provided the most essential and the most extensive information about the distribution of the species. A detailed list of the sites of the species examined can be found in the database of the program which gathers information about the distribution of alien naturalized species, the so-called neophytes or kenophytes (ATPOL-KENO). The program is an integral part of the national database of ATPOL. A map of the distribution of *A. artemisiifolia* in Poland was published in “Distribution Atlas of Vascular Plants in Poland” (Tokarska-Guzik, 2001). The map shown here contains further additions (Fig. 1). These data were gathered for the Silesian Uplands, as for the whole country, by means of the cartogram method (Fig. 2). However, in this case a square with a side of 2 kilometres was a basic unit (the data for Poland are gathered in squares with a side of 10 kilometres (Tokarska-Guzik et al. 2011; Zając, 1978; Zając and Zając, 2001).

* Acronyms for herbaria are given after Mirek et al. (1997):

KTU – Department of Plant Systematics, University of Silesia
LBL – Department of Systematics and Phytogeography, Institute of Botany, Maria Curie-Skłodowska University in Lublin
MGS – Upper Silesian Museum
WRSL – Museum of Natural History, University of Wrocław

RESULTS

The ragweed pollen season in Sosnowiec in 1998-2010 was extended from August to the middle of October. The pollen season started between 30th June and 15th August. Its onset was recorded earliest in 2007 (30th June) and latest in 2005 (15th August). The length of pollen seasons ranged from 41 days in 2008 to 103 days in 2007 (Table 1). The average length of pollen seasons was 63 days.

The Spearman’s rank correlation between meteorological parameters and the length of pollen seasons showed a positive correlation between the level of precipitation and the length of the ragweed pollen season (Table 2). There were also significant positive correlations between the length of the pollen season and the number of days with a stationary front and with occurrences of polar maritime transformed air masses (Table 3).

The course of the ragweed pollen seasons varied over the studied years. An analysis of dynamic curves showed that the presence of pollen in the air of Sosnowiec was discontinuous. There were several-day breaks between days with the presence of pollen. The period of concentrated pollen release and the highest pollen counts covered various time ranges. The maximum pollen counts were in the last ten days of August or in the first half of September. The daily maximum was recorded earliest in 2000 (19th August) and as late as on 20th September in 2001 (Table 1). The maximum difference between the years was thus 32 days.

The values of maximum daily pollen counts varied in different years and ranged from 18 to 222 grains x m^{-3} (Fig. 3). The average daily count in the 12 years examined was 83 grains x m^{-3}. During the 1998–2010 pollen seasons, on the majority of days the ragweed pollen count was low, not exceeding 20 grains x m^{-3}. High counts were recorded only on single days. The highest daily pollen count was recorded in 1999 and the lowest in 2001 (Table 1). A daily maximum exceeding 100 grains x m^{-3} happened only three times - in 1999, 2002, and 2005 (Fig. 3). An analysis of daily variability in the ragweed pollen count from 2003 to 2010 showed that the highest pollen counts were between 11 p.m. and 9 a.m. (Fig. 4), except in 2003, when the highest counts were between 12 a.m. and 3 p.m..

A statistical analysis showed that the daily ragweed pollen count depended on the wind direction – the higher counts were recorded when the prevailing winds were from the south, east and south-east (Table 4). Maximum air temperature turned out to be the most important among other meteorological parameters. It had a positive impact on the pollen counts (Table 5). The highest negative correlations were found with wind from the west and with the relative humidity of the air. It is important to add here that in spite of the high level of significance ($\alpha<0.001$) the values of the correlation coefficients are very low.

Air masses coming from the west had a negative impact on the maximum values of pollen (Table 6). Concerning the types of air masses, a negative correlation was found with the frequency of days with an inflow of fresh polar maritime air and with the frequency of days with a cold front (Table 7).

The sum of the daily pollen counts in the whole ragweed pollen season (the Seasonal Pollen Index) varied from year to year (Fig. 5). It ranged from 114 grains in 2001 to 950 grains in 1999. A high Seasonal Pollen Index was also recorded in 2002, 2004 and 2008, but all were little more than half of the value obtained in 1999 (Table 1). The average annual sum in the 12 studied years was 352 grains. Air masses coming from the west had a negative impact on the annual sums of the pollen grains (Table 8). The ragweed pollen season in 1999 (the highest SPI) was characterized by a low rate of air mass inflows from the west. In this year, the highest number of days with a warm front, comparing all years, was noted as well as high temperature and high insolation were also recorded.

The results concerning the influence of wind direction and the impact of air masses are reflected in the distribution of *A. artemisiifolia* in the Silesian Uplands area. The sites of the species are still rare and scattered (Fig. 1 and 2). However, it is worth noting that a few new sites of this species have been found in recent years. They are situated along the road Cieszyn-Katowice running to the south (K o s z e l a et al. 2009; T o k a r s k a - G u z i k et al. 2011; T o k a r s k a - G u z i k 2007, *herb*. KTU).

Table 1.
Characteristics of *Ambrosia* pollen seasons in Sosnowiec, 1998-2010

Year	Period of pollen occurrence	Length of pollen season (days)	Pollen grain concentration on a peak day	Peak day	Annual total pollen grains
1998	2.08-26.09	56	63	12.09	213
1999	8.08-29.09	52	222	4.09	950
2000	22.07-1.10	71	75	19.08	356
2001	8.08-10.10	63	18	20.09	114
2002	27.07-30.09	65	127	4.09	474
2003	27.07-28.09	63	59	29.08	215
2004	11.08-4.10	54	79	30.08	462
2005	17.08-8.10	52	114	7.09	390
2006	12.08-17.10	66	48	24.08	348
2007	30.06-11.10	103	40	23.08	156
2008	5.08-15.09	41	82	6.09	448
2009	27.07-22.10	87	61	26.08	267
2010	3.08-24.09	52	90	24.08	185
Average	1.08-3.10	63	83	1.09	352

Table 2.
Spearman's correlation between the length of the pollen season and the meteorological parameters in 1998-2010

Temperature (°C)				Rainfall (mm)	Humidity (%)	Insolation (h)	Average wind speed (m/s)	Max. wind speed (m/s)
medium	minimum	maximum	above ground level (5cm)					
-0.30	-0.14	-0.37	0.05	0.69*	0.12	-0.63*	0.10	0.01

**α<0.001; *α<0.05

Table 3.
Spearman's correlation between the types of air masses and weather fronts and the length of the pollen season in 1998-2010

PPms	PPmc	PPm	PPk	PA	PZ	rmp	z	c	o	rf	st	–
0.64*	-0.03	0.38	0.21	-0.54	0.06	0.28	0.39	-0.52	-0.02	-0.04	0.66*	-0.34

**α<0.001; *α<0.05

PPms polar maritime old (transformed) air masses; *PPmc* polar maritime warm; *PPm* polar maritime fresh; *PA* arctic air masses; *PPk* polar continental; *PZ* tropical air masses; *rmp* various air masses; *z* cold front; *c* warm front; *o* occlusion front; *rf* various fronts; *st* stationary front; – no front

Table 4.
Spearman's correlation between the daily pollen counts and the wind direction in 1998-2010

N	NE	E	SE	S	SW	W	NW	C
-0.11*	0.02	0.20**	0.33**	0.23**	-0.03	-0.22**	-0.19**	0.16**

**α<0.001; *α<0.05

Table 5.
Spearman's correlation between the daily pollen counts and the meteorological parameters in 1998-2010

Temperature (°C)				Rainfall (mm)	Humidity (%)	Insolation (h)	Average wind speed (m/s)	Max. wind speed (m/s)
medium	minimum	maximum	above ground (level 5cm)					
0.21**	0.08	0.27**	-0.02	-0.14**	-0.21**	0.21**	-0.09*	-0.09*

***α<0.001; *α<0.05*

Table 6.
Spearman's correlation between the directions of air masses and the maximum count of pollen grains in 1998-2010

N	NE	E	SE	S	SW	W	NW	v	x
-0.06	0.52	0.43	0.56	-0.18	0.05	-0.78*	-0.25	-0.35	0.32

***α<0.001; *α<0.05*

v variable wind direction; x unclassified situations

Table 7.
Spearman's correlation between the types of air masses and weather fronts and the maximum count of pollen grains in 1998-2010

PPms	PPmc	PPm	PPk	PA	PZ	rmp	z	c	o	rf	st	–
-0.36	-0.30	-0.72*	0.58	0.55	0.01	0.22	-0.64*	0.19	-0.27	-0.24	-0.36	0.64*

***α<0,001; *α<0,05*

PPms polar maritime old (transformed) air masses; PPmc polar maritime warm; PPm polar maritime fresh; PA arctic air masses; PPk polar continental; PZ tropical air masses; rmp various air masses; z cold front; c warm front; o occlusion front; rf various fronts; st stationary front; – no front

Table 8.
Spearman's correlation between the directions of air masses and the annual total of pollen grains in 1998-2010

N	NE	E	SE	S	SW	W	NW	v	x
0.02	0.36	0.39	0.43	-0.19	0.16	-0.82*	-0.19	-0.27	0.18

***α<0,001; *α<0,05*

v variable wind direction; x unclassified situations

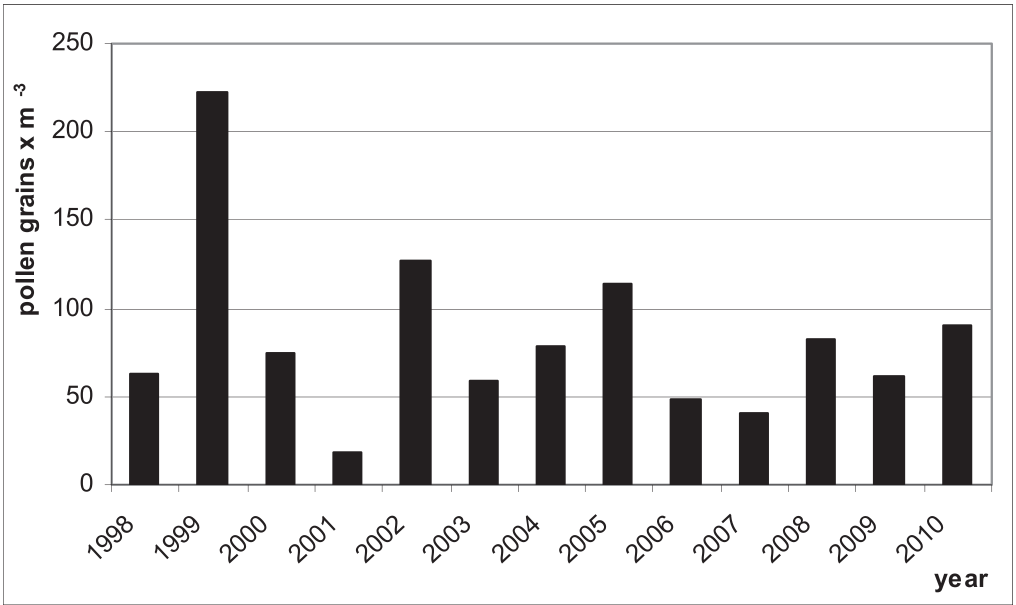


Fig. 3. The maximum count of pollen grains in 1998-2010.

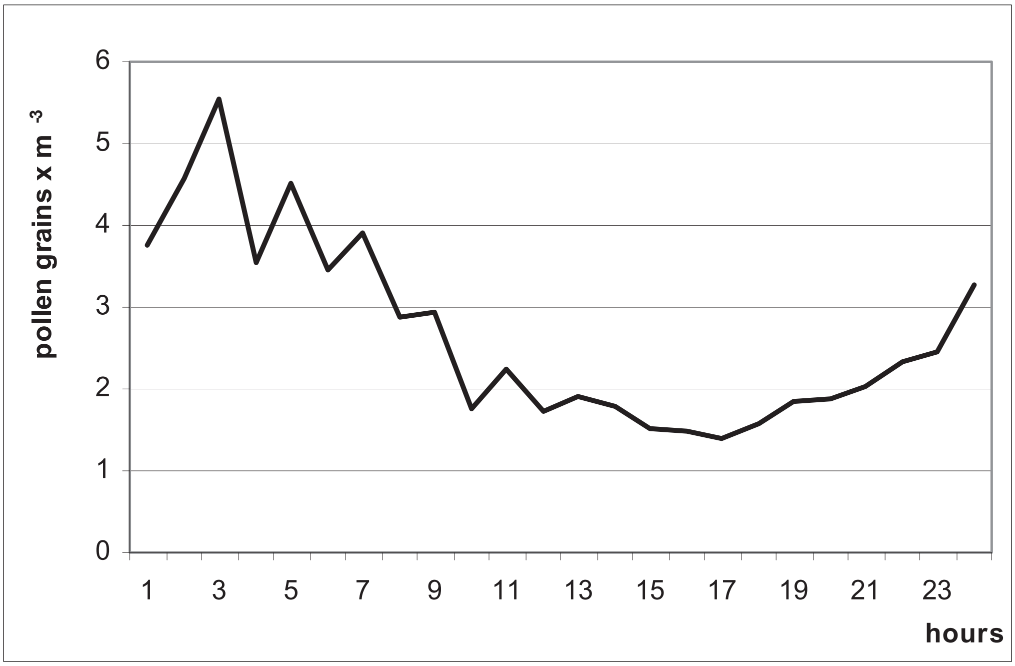


Fig. 4. Concentration of ragweed pollen grains per day (average of 1998-2010).

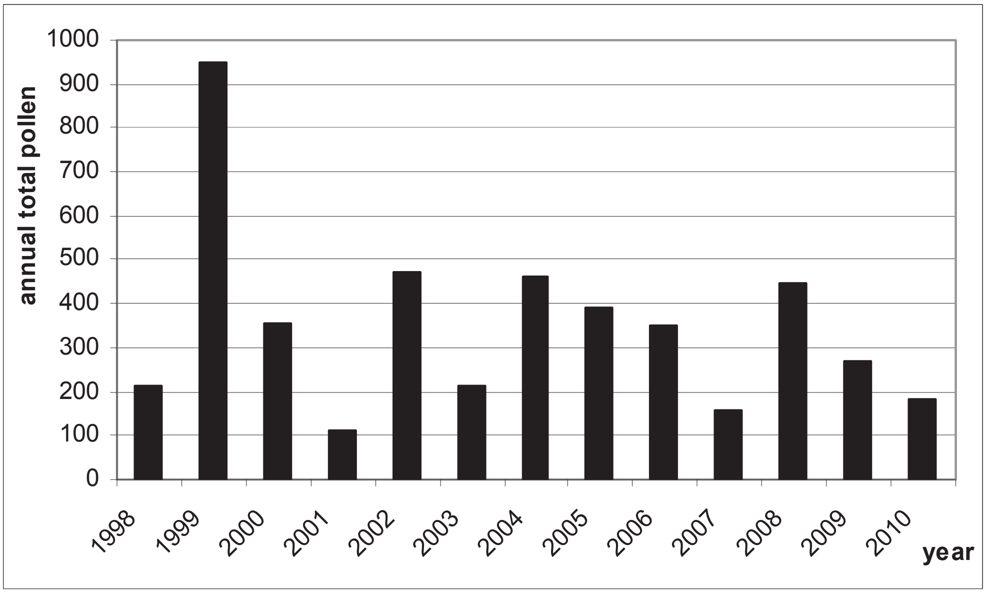


Fig. 5. The Seasonal Pollen Index in 1998-2010.

DISCUSSION

The observations of ragweed pollen in the air of Sosnowiec performed over a period of twelve years show variation in the onset and length of the pollen season and also fluctuations in the pollen counts.

The studies performed in many countries where ragweed is prevalent have shown a relationship between the aerial pollen count for this species and meteorological parameters, especially with regard to temperature, precipitation, and humidity (Laaidi et al. 2003; Makra et al. 2004; Peternal et al. 2005; Piotrowska and Weryszko-Chmielewska, 2006; Puc, 2004, 2006; Stach et al. 2000; Stark, 1997; Stępalska et al. 2002). In the present investigation, only certain meteorological factors showed a statistically significant relationship with the pollen count. In all cases, the values of the correlation coefficients were low in spite of the high level of significance. With regard to the daily count, the meteorological parameters had a limited impact on the fluctuations of ragweed pollen concentrations in the air. The strongest correlations were found with maximum temperature and with the wind direction from the south and south east. Similar relationships for ragweed pollen in Rzeszów were found by Kasprzyk (1996). In almost all the years, it was observed that the highest pollen counts occurred when air maximum temperature was above 25°C, which was also found in Szczecin (Puc, 2004, 2006). However, in Lublin the highest concentrations of pollen were observed when maximum temperature exceeded 21°C (Piotrowska and Weryszko-Chmielewska, 2006).

Higher correlation coefficients, but with lower relevance, were obtained analyzing other characteristics of the ragweed pollen season. A high negative correlation coefficient between the frequency of inflows of air masses from the west and the value of the annual sum of pollen grains and the value of the maximum daily count was found. Polar maritime air masses had an impact on the duration of the ragweed pollen season and the maximum daily count. When there was an inflow of this type of air, the pollen seasons were longer and the seasonal maxima lower. The polar maritime air arrives in Poland from the west, from over the northern part of the Atlantic Ocean and therefore it is characterized by considerable humidity. In summer, it brings cold weather and cumulus clouds with thunderstorms. Furthermore, this would explain the positive correlation of rainfall with the length of the pollen season. Longer seasons were also found in the years when there were many days with a stationary front, which is not moving or is moving with a speed lower than 2 m x s^{-1}.

A ragweed pollen grain is small and has good buoyancy characteristics. It can be carried by the wind over long distances. The closest certain sites of *Ambrosia* L. are at a distance of 25-40 kilometres from the sampling point, which could be evidence that the pollen comes not only from local sources, but is also carried from distant places. It cannot be excluded that the pollen arrives from the Czech Republic, Slovakia, Ukraine and Hungary. Significant correlations with the frequency of inflow of air masses do confirm that the ragweed pollen grains recorded in Sosnowiec were most probably carried from distant places. An increase in maximum counts on the days when the wind from the south and south-east was predominant also suggests that the pollen is being carried from distant places. Cecchi (2007) considered it possible that pollen is carried together with moving air masses from

Hungary to the central part of Italy. The fact that the highest pollen counts in Sosnowiec were recorded at night and in the morning also suggests that the pollen is being carried from distant places. In Poznań (Stach et al. 2000, 2007), Rzeszów (Kasprzyk, 2008), and Lublin (Piotrowska and Weryszko-Chmielewska, 2006), ragweed pollen was also recorded at night and early in the morning. However, in Hungary (Vitányi et al. 2003) and Croatia (Peternel et al. 2005), where ragweed grows abundantly, the daily maxima were recorded at midday. Also in France, the presence of pollen was found in the morning (9-11 a.m.) (Laaidi et al. 2003). In Poland, high pollen counts are recorded in Lublin every year, although ragweed sites have not been found. This may confirm the fact that the pollen is carried from distant places, in this case from Ukraine (Piotrowska and Weryszko-Chmielewska, 2006), although new localities of *A. artemisiifolia* have been recorded in the Lublin region recently (personal inf. by F. Święs), mainly along railways.

The plant pollen does not appear to pose a significant threat to the inhabitants of the region, probably due to the fact that the number of *Artemisia artemisiifolia* sites found in the region is still low. No increase in ragweed pollen counts in Sosnowiec was found over the monitored period. However, the fact that new sites of this species are found and the fact that there is a possibility of pollen inflow from other regions of Europe where this species already poses a serious threat make it necessary to regularly monitor ragweed pollen concentrations in the air and to control the spread of the species in the region.

CONCLUSIONS

1. The ragweed localities closest to Sosnowiec were found along the national road between Katowice and Cieszyn at a distance of approximately 25–40 kilometres SW from the sampling point and one locality was confirmed on a railway siding in Tarnowskie Góry at a distance of approximately 25 kilometres NW from the sampling point.
2. The impact of meteorological parameters on changes in pollen counts was weak. The highest positive correlation was found between maximum temperature and the wind direction from the south, east and southeast, and the daily concentration of ragweed pollen.
3. A high negative correlation was found between the frequency of the inflow of air masses from the west and the maximum concentration and SPI for ragweed pollen.
4. The highest pollen counts were recorded mostly at night and early in the morning, which suggests that pollen comes from long transport, not only from local sources.

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Ocena zagrożenia pyłkiem *Ambrosia* L. w skali regionalnej na przykładzie miasta Sosnowca (Wyżyna Śląska, Polska).

Streszczenie

Badania koncentracji pyłku *Ambrosia* w powietrzu Sosnowca prowadzono w latach 1998-2010 metodą wolumetryczną. Początek sezonu pyłkowego *Ambrosia*, wyznaczony metodą 98%, rozpoczynał się na przełomie lipca i sierpnia i trwał do końca października. Wysokie koncentracje pyłku notowano najczęściej w trzeciej dekadzie sierpnia lub w pierwszej połowie września. Najwyższe stężenie pyłku *Ambrosia* odnotowano w 1999 roku (222 ziarn x m^{-3}), najniższe w 2001 roku (18 ziarn x m^{-3}). Wykazano, iż stężenie dobowe ziarn pyłku zależało od kierunku wiatru i temperatury maksymalnej powietrza. Najsilniejszą korelację stwierdzono dla temperatury maksymalnej i dla kierunku wiatru z południowego wschodu. Znaleziono wysoki ujemny współczynnik korelacji między częstością napływu mas powietrza z zachodu a wartością sumy rocznej ziarn pyłku oraz z wartością maksymalnego stężenia. Stwierdzono również oddziaływanie masy powietrza polarno-morskiego na długość sezonów pyłkowych i na wartości maksymalnego stężenia *Ambrosia*. Przy napływie tego typu powietrza notowano dłuższe sezony pyłkowe oraz niższe maksima sezonowe. Stanowiska z *Ambrosia* zostały stwierdzone w odległości 25-40 km na SW i NW od punktu pomiarowego. Istotne korelacje z częstością napływu mas powietrza mogą potwierdzać fakt, iż ziarna pyłku *Ambrosia* rejestrowane w Sosnowcu pochodzą nie tylko z lokalnych źródeł ale również z dalekiego transportu.